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Mineral and antinutritional composition of fermented water yam (*Dioscorea alata*)

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ABSTRACT
Water yam *Dioscorea alata* samples were subjected to liquid substrate natural fermentation at $30^0\pm 2^0$C for 120hours. The mineral composition, antinutrient composition and pH of the raw and fermented samples were determined using standard methods. The values of various mineral and antinutrient content determined show significance differences either increasingly or decreasingly ($p\leq0.05$). The calcium content increased significantly ($p\leq0.05$) from $23.35^a\pm0.07$mg/100g raw (unfermented) sample to $50.05^f\pm0.07$mg/100g fermented sample. The magnesium contents also increased as fermentation progressed with the highest value recorded on the sample fermented for 120hours ($45.00^e\pm0.00$mg/100g). Fermentation also bring about an increase in the potassium contents, which was observed to have increased from $260.00^a\pm$ 0.00mg/100g raw to $285.00^f\pm0.00$mg/100g. The values of phosphorus also increased with fermentation until the termination of the experiment and the values ranged between $187.10^a\pm0.14$mg/100g raw samples to $219.55^e\pm0.64$mg/100g. The sodium and iron contents also increased significantly with fermentation and the values ranged between $196.00^a\pm0.00$ to $235.10^e\pm0.14$mg/100g and $18.00^a\pm0.00$ to $38.01^c\pm0.01$mg/100g for sodium and iron respectively. Of all the mineral contents determined potassium was observed to have recorded the highest values ($285.00^f\pm0.00$mg/100g) followed by sodium and phosphorus. In all iron was observed to be the lowest mineral values determined (18.00mg/100g). Antinutrient analysis revealed that there was no significant change ($P\leq0.05$) in phytate content of the raw unfermented sample and the fermented sample values is $564.12^a\pm0.01$, evaluation of the oxalate and the tannin content showed that the value decreased as fermentation progressed. The values ranged between $3.42^f\pm0.01$ to $1.55^a\pm0.03$ for the oxalate content and $0.37^c\pm0.01$ to $0.22^a\pm0.03$ for tannin. The pH values decreased as fermentation progressed. However, fermentation had given us better acceptable products in respect to improvement in the mineral composition and reduction in the antinutrient composition of the water yam sample used in this research.

Key words: water yam, *liquid substrate, fermentation, mineral, antinutrient, Dioscorea alata*

INTRODUCTION

Water yam is an herbaceous, high climbing vine that can grow to 65 ft. long. Its stem is twining, branching, and hairless, with winged, reddish leaf nodes. Leaves are thin, hairless, 4 to 8 in. long, 2 to 6 in. wide, heart-shaped to triangular with elongated tips, and can be arranged alternately or oppositely along the stem. They have long petioles, smooth margins, and basal lobes that are often angled, and are dark green with slightly indented curved veins above (giving a quilted appearance) and lighter green beneath. Rare, small, male and female flowers may appear in panicles or spikes on separate plants between May and August. Flowers are green to white and fragrant. Rough-textured, oblong aerial tubers (bulbils) about 1.2 in. wide and 4 in. long resembling miniature potatoes are the most notable fruit, with 1 to 4 occurring at leaf axils. Fruits drop and sprout to form new plants. Water yam also spreads and persists by underground tubers. It grows rapidly on open to semi shady sites. Plants die back during winter, but are able to cover small trees in a year, with old vines providing trellises for re growth.

Water yam (Dioscorea alata) is one of the most economically important yam species, which serves as a staple food for millions of people in tropical and subtropical countries [1]. D. Alata is popular and prevalent within Abakaliki agro ecological zone of Ebonyi State, Nigeria where it is called “Mbala or Nvula” (Igbo names). They are consumed boiled, roasted, fried or pounded and eaten in association with protein rich sauces. D. alata can also be processed into flour and reconstituted into fufu dough. Generally, they contain less sugar and have an extended shelf life [2], which ensure availability in periods of scarcity. Five high yielding and disease resistant water yam varieties developed by International Institute of Tropical Agriculture (ITTA) and two landraces were evaluated within Abakaliki agro ecological zone [3]. Most of these improved varieties showed remarkable potential for high yield over the landraces. This suggests a possible preference of local farmers for the new varieties over the landraces that were selected because of high yield. It also indicates progress in breeding for higher yield and disease resistance by the Research Institutes.

Fermentation in food is the conversion of carbohydrates into alcohols or acids.

Fermentation usually implies that the action of the microorganisms is desirable, and the process is used to produce alcoholic beverages such as wine, beer, and cider. Fermentation is also employed in preservation to create lactic acid in sour foods such as pickled cucumbers, kimchi and yogurt.

The primary benefit of fermentation is the conversion of sugars and other carbohydrates, e.g., converting juice into wine, grains into beer, carbohydrates into carbon dioxide to leaven bread, and sugars in vegetables into preservative organic acids.

Food fermentation has been said to serve five main purposes: [4].

- Enrichment of the diet through development of a diversity of flavors, aromas, and textures in food substrates.
- Preservation of substantial amounts of food through lactic acid, alcohol, acetic acid and alkaline fermentations.
- Biological enrichment of food substrates with protein, essential amino acids, essential fatty acids, and vitamins.
- Detoxification during food-fermentation processing.
- A decrease in cooking times and fuel requirements.

Fermentation has some uses exclusive to foods. Fermentation can produce important nutrients or eliminate antinutrients.[5]. Food can be preserved by fermentation, since fermentation uses up food energy and can make conditions unsuitable for undesirable microorganisms. For example, in pickling the acid produced by the dominant bacteria inhibit the growth of all other microorganisms. Depending on the type of fermentation, some products (e.g., fusel alcohol) can be harmful to people's health.[6]. In view of this, this research is aiming at evaluating the effect of fermentation on the mineral and antinutrient composition of water yam (Dioscorea alata)

MATERIALS AND METHODS

The water yam used for this research was bought from Lafenwa market, Abeokuta, Ogun state Nigeria.

Sample preparation

The water yam samples after proper identification was peeled and washed thoroughly with sterile distilled water to remove dirt and other contaminant. Before subjecting to fermentation 500g of the sample was weighed, this serves as the unfermented sample. Parameters such as the pH, mineral and antinutrient composition were determined by method of [7].

Fermented sample was prepared by dividing the remaining peeled and cleaned water yam sample into five places of 500g each. Each of the samples were then submerged into 500ml of clean sterile distilled water in a separate sterile plastic container and labelled day 1 to 5 and the plastic container was properly covered for liquid substrate fermentation to take place at room temperature over a period of five days, 24, 48, 72, 96 and 120hours respectively. The pH was measured using pH meters, antinutrient and the mineral contents were determined at 24hours interval for period of 5 days. Atomic absorption spectrophotometer (pye Unicam SP9 AAS) was used for the determination of calcium, magnesium, iron, potassium, phosphorus. Etc. Antinutrient compositions were determined by method of [8]. All the data generated were subjected to statistical analysis using the method of [9, 10].

RESULTS

Table 1. Shows the mineral composition of raw (unfermented) and fermented sample of water yam at ($p \leq 0.05$). The calcium content of the raw (unfermented) sample was 22.35^{a}±0.07, while the one fermented for 24hours was 26.25 ^{b}±0.40. The calcium contents of the samples fermented for 48,72,96 and 120 hours were; 29.01 ^{c}±0.02; 34.02 ^{d}±0.02;40.00 ^{e}±0.00 and 50.05 ^{f}±0.07 respectively.

The value of magnesium content of the raw (unfermented) sample was 27.30 ^{a}±0.00, the value of the magnesium content obtained from the sample fermented for 24 hours was 29.30 ^{b}±0.14, those fermented for 48, 72, 96 and 120 hours recorded the values of; 30.01 ^{b}±0.01; 31.54 ^{c}±0.65; 37.57 ^{d}±0.61; and 45.00 ^{e}±0.00 respectively.

The potassium content value of the raw sample was 260.00 ^{a}±0.00 while values obtained from the fermented samples ranged between 261.00 ^{a}±0.00 and 285.00 ^{f}±0.00.

The raw sample had phosphorus content of 187.10 ^{a}±0.14, no change in value was observe after fermenting for 24hours. The samples fermented for 48, 72,96 and 120 hours had potassium content of 190.59 ^{b}±0.71; 198.10 ^{c}±0.14; 206.00 ^{d}±0.00 and 219.55 ^{e}±0.64 respectively. Sodium contents of the raw (unfermented) sample was 196.00 ^{a}±0.00; while an increase in value was observed for the sample fermented for 24hours and the value was 197.90 ^{a}±1.27, the sample fermented for 48hours increased to 201.50 ^{b}±0.17 while those fermented for 72,96 and 120 hours also follow similar trend.

The iron content of the raw (unfermented) sample was 18.00 ^{a}±0.00, while those fermented for 24, 48, 72, 96 and 120 ranged between 20.15 ^{b}±0.08 and 38.01 ^{c}±0.01.

TABLE 1: Mineral composition of water yam (Dioscorea alata) mg/100g.

Fermentation Period(h)	Ca	Mg	K	P	Na	Fe
0	22.35^{a}±0.07	27.30^{a}±0.00	260.00^{a}±0.00	187.10^{a}±0.14	196.00^{a}±0.00	18.00^{a}±0.00
24	26.25^{b} 0.40	29.30^{b}±0.14	261.50^{b}±0.71	187.15^{a}±0.21	197.90^{a}±1.27	20.15^{b}±0.08
48	29.0^{c} ±0.02	30.01^{b}±0.01	265.10^{c}±0.14	190.50^{b}±0.71	201.50^{b}±0.71	24.04^{c}±0.06
72	34.02^{d} ±0.00	31.54^{c}±0.65	268.05^{d}±0.07	198.10^{c}±0.14	210.50^{c}±2.12	27.00^{d}±0.00
96	40.00^{e} ±0.00	37.57^{d}±0.61	277.95^{f}±0.07	206.00^{d}±0.00	222.05^{d}±0.07	31.55^{e}±0.64
120	50.05^{f} ±0.07	45.00^{e}0.00	285.00±0.00	219.55^{e}±0.64	235.10^{e}±0.14	38.01^{c}±0.01

Values are mean of triplicate determination

Table 2: Antinutrient composition of raw and fermented samples of water yam

Fermentation period (h)	Phytate	Oxalate	Tannin	pH
0	564.12^{a}±0.01	3.42^{f}±0.01	0.37^{c}±0.01	7.14^{a}±0.01
24	564.11^{a}±0.00	2.98^{e}±0.01	0.31^{b}±0.01	6.34^{b}±0.01
48	564.12^{a}±0.02	2.89^{d}±0.01	0.26^{a}±0.01	5.98^{d}±0.02
72	564.11^{a}±0.00	2.61^{c}±0.01	0.24^{a}±0.01	5.34^{c}±0.01
96	56412^{a}±0.01	2.15^{b}±0.01	0.24^{a}±0.02	4.98^{d}±0.04
120	56417^{a}±0.02	1.55^{a}±0.02	0.22^{a}±0.03	4.00^{d}±0.01

Values are mean of triplicate determination

Antinutrient composition of raw unfermented sample of water yam *Dioscorea alata*

Evaluation of the antinutrient content revealed that there was no significant different ($P \leq 0.05$) in the phytate content of the raw and fermented sample and the value was 564.12^{a}±0.01.

The oxalate content of the raw sample is 3.45^{f}±0.01, while the value of those samples fermented for 24hrs, 48hrs, 72hrs, 96hrs and 120hrs were 2.98^{e}±0.01, 2.89^{d}±0.01, 2.61^{c}±0.01, 2.15^{b}±0.01 and 1.55^{a}±0.02. Tannin content of the raw sample was 0.37^{c}±0.01 while the tannin content of the fermented sample ranged between 0.37^{c}±0.01 and 0.22^{a}±0.03. With the sample fermented for 120 hours having the lowest value (0.22^{a}±0.03). The pH value decrease as fermentation progressed and the values ranged between 7.14 and 4.00

DISCUSSION

The results obtained in this research revealed that various mineral values indicate significant differences and were observed to have showed remarkable increase in values. Potassium was observed to have recorded the highest values of all the mineral content analysed and the value was obtained from the sample fermented for 120hours. The value is 285.00±0.00mg/100g**.** Calcium increased from 22.35±0.07mg/100g to 50.05±0.07mg/100g. Magnesium analyses revealed an increase in value from 27.30±0.00 raw sample to 45.00±0.00mg/100g fermented sample. Phosphorus value increased from 187.10±0.14 to 219.55±0.64mg/100g. Sodium and iron also follow similar trend of value increase with fermentation.

In general the various mineral contents were highest in the entire sample fermented for 120hours. This shows that fermentation had greatly increased the mineral content. The increase in various mineral contents such as calcium, magnesium, potassium, iron, phosphorus and sodium of the various fermented sample analysed in this research may be as a result of the reduction in antinutrient content as fermentation progressed. This antinutrient normally bind with some metal like calcium and magnesium preventing there bioavailability. [11] reported that processing methods such as fermentation greatly reduced antinutrient content such as phytate and oxalate. The remarkable increase in various mineral content may also be attributed to the reduction in the microbial load as a result of microbial competition and decrease in pH as fermentation progressed which makes the environment inhabitable for the proliferation of some microorganisms to utilised the mineral availability in the sample[12].

The oxalate content value of the water yam sample at ($P \leq 0.05$) was observed to be decreasing with increase in the days of fermentation. This achievement could be attributed to the combined effect of various organisms involved during the natural fermentation. This reduction is great important because oxalate can form complex with most essential trace metals thereby making them unavailable for enzymatic activities and other metabolic processes [13]. [14] and [15] reported that the treatment such as fermentation can greatly reduced the antinutrient content in food sample.

Fermentation significantly reduce the tannin content ($P \leq 0.05$) with the sample fermented for 120 hrs having the lowest value (0.02^{a}±0.03) this reduction may be

attributed to the fact that the enzymes produced by the microorganisms that involved in the fermentation helps to hydrolyze complex organic compound in the substrate there by making the substrate less toxic. Tannins are capable of lowering available protein by antagonistic competition and can therefore elicit protein deficiency syndrome, kwashiorkor [16]. [17] reported that most popular toxicant can be reduced by processing method such as fermentation. It can be observed from the result of this research that there was no significant different ($P \leq 0.05$) in the phytate level even though as fermentation progressed. This means that fermentation seems not have effect on the phytate level of the fermenting substrate.

However, it can be observed that fermentation has given us a better acceptable product in respect to improvement of mineral composition of water yam and reduction in the antinutrient content of the water yam used in this research.

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